DIGITAL COMPUTER NEWSLETTER

The purpose of this newsletter is to provide a medium for the interchange among interested persons of information concerning recent developments in various digital computer projects. Distribution is limited to government agencies, contractors, and contributors.

OFFICE OF NAVAL RESEARCH · MATHEMATICAL SCIENCES DIVISION

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Editorial Policy Notices

CURRENT PUBLICATION PLAN

Because of staffing problems the Digital Computer Newsletter was not published in October 1962 and during 1963. Commencing with the January 1964 issue, however, the normal quarterly schedule was resumed.

EDITORIAL

The Digital Computer Newsletter, although a Department of the Navy publication, is not restricted to the publication of Navy-originated material. The Office of Naval Research welcomes contributions to the Newsletter from any source. The Newsletter is subjected to certain limitations in size which prevent publishing all the material received. However, items which are not printed are kept on file and are made available to interested personnel within the Government.

DCN is published quarterly (January, April, July, and October). Material for specific issues must be received by the editor at least three months in advance.

It is to be noted that the publication of information pertaining to commercial products does not, in any way, imply Navy approval of those products, nor does it mean that Navy vouches for the accuracy of the statements made by the various contributors. The information contained herein is to be considered only as being representative of the state-of-the-art and not as the sole product or technique available.

CONTRIBUTIONS

The Office of Naval Research welcomes contributions to the Newsletter from any source. Your contributions will provide assistance in improving the contents of the publication, thereby making it an even better medium for the exchange of information between government laboratories, academic institutions, and industry. It is hoped that the readers will participate to an even greater extent than in the past in transmitting technical material and suggestions to the editor for future issues. Material for specific issues must be received by the editor at least three months in advance. It is often impossible for the editor, because of limited time and personnel, to acknowledge individually all material received.

CIRCULATION

The Newsletter is distributed, without charge, to interested military and government agencies, to contractors for the Federal Government, and to contributors of material for publication.

For many years, in addition to the ONR initial distribution, the Newsletter was reprinted by the Association for Computing Machinery as a supplement to their Journal and, more recently, as a supplement to their Communications. The Association decided that their Communications could better serve its members by concentrating on ACM editorial material. Accordingly, effective with the combined January-April 1961 issue, the Newsletter became available only by direct distribution from the Office of Naval Research.

Requests to receive the Newsletter regularly should be submitted to the editor. Contractors of the Federal Government should reference applicable contracts in their requests.

All communications pertaining to the Newsletter should be addressed to:

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Digital Computer Newsletter
Informations Systems Branch
Office of Naval Research
Washington, D. C. 20360

Computing Centers

Computer for Medical Research and Diagnosis

University of Missouri
Columbia, Missouri 65202

The University of Missouri School of Medicine has initiated a broad new program designed to investigate new uses of electronic computers in medical teaching, research, patient diagnosis, and care. Dean Vernon E. Wilson said the new program has been made possible through the recent installation of an IBM 1410 computing system which includes a central processing unit, a 28 million character random access memory, five magnetic tape drives, and peripheral punch card equipment.

The new computer program is under the direction of Donald A. B. Lindberg, M.D., assistant professor of pathology. The initial objective of the new program is to investigate methods of converting significant medical data on patients at University Hospital into a form which can be stored and retrieved by the computer. Once the data has been translated into a computer-accessible form, it would be available to all the professional staff for teaching, research, and patient care.

One advantage of the 1410 computer system is that with it all patient record data can be stored on magnetic tape, where it is made easily accessible and can be quickly updated. Such medical records become increasingly valuable also for research purposes as more and more medical information is added.

One of the first major phases of the computer program will be to incorporate the new computer into the Medical Center communications network which transmits hospital laboratory data throughout the hospital. The most important improvement in the communications system will be the increased speed afforded by the computer in getting laboratory reports back to patients' physicians, and in increasing the value of such reports. More detailed information can be included in the reports and some preliminary evaluation of the laboratory data can be done automatically by the computer.

Along educational lines the computer system will be used to teach students in pathology how to use the computer to obtain and evaluate existing records of patients that are cared for at the Medical Center. Other immediate programs include the evaluation of X-ray diagnostic data and a study of diagnostic aspects of words and phrases used in the medical records of patients.

The purpose of the computer project is basically to investigate the proper role of electronic data processing techniques in the teaching and practice of medicine. Dr. Lindberg considers modern electronic computers to have a great potential in handling information of all kinds, and no one can presently predict their possible contribution to medicine. In this respect, the University of Missouri is in the forefront among institutions of higher education in making a commitment to adapt electronic computers to the needs of both medical education and medical practice. The faculty and staff of the School of Medicine have an opportunity to help shape the future practice of medicine by their utilization of this equipment.

SEAC Retirement

National Bureau of Standards
Washington, D.C. 20234

Over 300 scientists, engineers, and technicians gathered at the National Bureau of Standards (U.S. Department of Commerce) April 23 at ceremonies marking the retirement of SEAC, the National Bureau of Standards Electronic Automatic Computer.[1]

When completed in 1950, SEAC was the first internally programmed digital computer to go into operation in the United States. Developed originally to enable the Air Force to attack massive logistic problems, SEAC was also used to perform computations required in the design of the first H-bomb.

SEAC has since been used in a wide variety of computer research, including experimentation in automatic searching of chemical patents and the manipulation of pictorial data, and in such novel tasks as moving "cars" on streets existing only in the computer memory. SEAC demonstrated the feasibility of techniques important to further computer development, which contributed to successive generations of computers.

SEAC is being retired not because of an inadequate "up-time" record but rather because current problems and experiments call for the higher processing speeds and the much larger memories that are feasible today. Although assembled only 14 years ago, SEAC is exceedingly old for an electronic computer. SEAC is nonetheless still regarded with affection by those who fashioned and cared for her, as well as by numerous scientists who were first introduced to the benefits of automatic calculation through SEAC.

SEAC remained in service this long partly because, as an experimental installation, her capabilities were increased several times and in unusual ways during her operational life. For example, the original acoustic memory of 512 words of 45 bits with an access time of 168 μseconds per word was doubled, and a Williams storage-tube memory of 512 words, which was soon increased to 1024, with access time of 60 μ seconds was incorporated to provide a hybrid memory of 2048 words. The original circuitry in SEAC used a 1 MHz (1 Mc) clock rate which was so effective that it was adapted for use in DYSEAC, a direct descendant completed in 1954, and was further modified for a third-generation processor called the PILOT, which is replacing the SEAC as an NBS research tool. Each of these systems had a progressively more dramatic extension of machine power through its novel logical organization.

The recent retirement ceremony was held almost 14 years after the ceremonies on June 20, 1950 in which the fully operational "interim" SEAC was formally dedicated at the National Bureau of Standards. Many of those who had been present at the dedication were able to attend the retirement. The joint hosts at the retirement ceremonies were Dr. E. W. Cannon, Chief of the NBS Applied Mathematics Division, and Samuel N. Alexander, who 14 years ago was chief of the section that produced SEAC. He is now Chief of the NBS Information Technology Division, until recently known as the Data Processing Systems Division.

Dr. Cannon introduced John Todd, who was Chief of the NBS Computation Section when SEAC came into operation. Mr. Todd described the early experiences of the mathematicians and scientists as they adjusted themselves to the power of this new tool. Mr. Alexander introduced Dr. Ralph J. Slutz, his assistant when SEAC was being designed and assembled. Dr. Slutz added anecdotes about those exciting days when SEAC was taking form and finally began to babble intelligently. He was followed by Mrs. Ida Rhodes, an enthusiastic pioneer in the use of SEAC, whose leave taking of the computer was spiced with humorous incidents that occurred in the early days of SEAC's operation.

The Department of Commerce Award for Exceptional Service, which the SEAC group received from Secretary Sawyer in 1951, also had a sequel in the retirement ceremonies. Each of the original recipients were presented with a special memento noting their presence at the SEAC retirement ceremonies.

James P. Nigro, Chief of the Engineering Applications Section which has current responsibility for SEAC and PILOT, acted as master of ceremonies for the retirement program. As

[1] Another computer, SWAC (Standards Western Automatic Computer), was developed by the Bureau's Institute for Numerical Analysis at the University of California (LA). SWAC differed in that it operated in parallel fashion rather than serially. SWAC used Williams-tube memory units, obtaining an access time of 8 μsec. SWAC was transferred to the University of California in 1954, where it is still in operation.

a finale, he presented a magnetic wire recording cartridge, a novel input unit of SEAC, to Dr. Uta Merzbach of the Smithsonian Institution's Museum of Science and Technology.

HISTORY OF SEAC

In the late 1940's the Bureau, which provides technical consultative and advisory services to other Federal agencies, had been requested by the Air Force to investigate and make recommendations for the use of computers to attack large-scale logistics problems and the associated program planning activities. NBS recommended a basic computer sufficient for an initial installation for the Air Force problems, and contracts were let to procure this computer system. When it became apparent that delivery would be delayed, the Air Force asked NBS to design an interim system and to fabricate it. Actual construction began in early 1949, and within 20 months of accepting the task the Bureau's Electronic Computers' Section finished the machine, which was named SEAC. Machine operation was checked out with surprisingly little debugging.

To perform the task for which it was first intended, SEAC was programmed to form a rough mathematical model of Air Force operations. This model was used by the Comptroller of the Air Force to evaluate the relation of each operation to the national military objectives and to determine its logistic requirements quickly. In January 1954 the Air Force turned SEAC over to NBS. SEAC also solved problems for many other groups in the Department of Defense and the Atomic Energy Commission. The subjects ranged from the selection of contract awardees to the degradation of the neutron.

SEAC has been used in a wide range of nonmilitary applications, such as the solution of the optical skew-ray problem, in which it traced each ray through 11 optical surfaces in only 10 seconds. Designers of optical systems were for the first time enabled to test proposed systems thoroughly in minutes, whereas before they could only sample a few rays in hours. The Bureau has been using SEAC in a continuing study, sponsored by the Patent Office, to investigate means of automating patent searching, especially ways of expressing topological descriptions of chemical compounds. The machine has also been valuable in studies aimed at developing computer techniques for automatic pattern recognition.

Recent applications include operating the computer so as to simulate "drivers' decisions" and to move "cars" to successive positions on a map of city streets carried in SEAC's memory. The simulation results in the computer memory were then displayed on an oscilloscope on which moving dots represented cars moving in rush hour traffic patterns. SEAC was operated in another program to determine the numbers, sizes, and form-factors of inclusions in pictorial material, making quantitative automatic metallographic and biological analyses possible.

Following the formal ceremonies those attending were invited to a demonstration of the SEAC facilities and to inspect DYSEAC and the PILOT data processing installation, after which many continued their reminiscences at a retirement banquet.

Computer Sharing Exchange and Service Center Established

National Bureau of Standards
Washington, D.C. 20234

A Computer Sharing Exchange and a Computer Service Center have recently been established at the National Bureau of Standards (U.S. Department of Commerce) on an experimental basis. The new facilities were created in response to a request of the Bureau of the Budget, which has found that great savings in both time and money can be realized through computer sharing.

The Sharing Exchange will coordinate requests of Federal Government agencies in the Washington, D. C. metropolitan area for help in locating appropriate computer time and services for their essential work. The Exchange will maintain records of the availability for sharing purposes of the electronic computer facilities of these agencies.

A similar experimental sharing exchange has been operating in Philadelphia, Penna. under Bureau of the Budget sponsorship. Up to now, the presence of the Philadelphia exchange has substantially increased the incidence and value of sharing among Government agencies there.

Because the Washington, D. C. area has by far the largest concentration and diversification

of computers in the United States, the Bureau has made available its Computation Laboratory as a Service Center in conjunction with the Sharing Exchange. This Center will provide its electronic equipment and personal services at cost to participating agencies to the extent permitted by present equipment and staff provided appropriate arrangements can be made. In addition, it will provide computer programming, problem analysis and formulation, and consultations in these areas. Requests will be considered for business, scientific, engineering, and other types of computer services. Services of the Center will be available either directly or through the Sharing Exchange. Unused time on the computer facilities of the Center will be available to the Exchange for sharing.

The Sharing Exchange and the Service Center will continue in operation for a trial period of 18 to 24 months. Although these facilities are intended to serve Federal Government agencies located in the Washington metropolitan area, their services will not necessarily be barred by distance.

Real-Time Computer System to Control Navy's World-Wide Supply Operations

U.S. Navy Bureau of Supplies and Accounts
Washington, D.C. 20360

A reduction in the lead time required to update a world-wide inventory of nearly 1 million items, and worth 3.5 billion dollars, from 2 months to 1 day will be accomplished by the U.S. Navy Bureau of Supplies and Accounts' (BUSANDA) new computer system.

Four UNIVAC 490 Real-Time systems, located at four Inventory Control Points (ICP) in the United States, will daily compute nearly 1 million inventory balances to determine resupply and re-order points.

This is the first large-scale real-time system to be used by the military for supply operations. Rear Admiral J. W. Crumpacker, Chief of BUSANDA, said that the Navy will be able to "reduce inventory substantially at a significant saving to the nation's taxpayers."

Benefits accruing to the Navy include:

1. Faster Response. The new system will update the inventory instantly. Such rapid response means that critical shortages can be pinpointed immediately, instead of the 2-week to 2-month delay that was routine with the previous system. Result: immediate action to replenish stocks.

2. Reduced Inventory. Faster response means the long lead time in placing orders is no longer necessary, and smaller inventories can now be carried. Inventory reductions are estimated to be many millions of dollars, thus permitting the Bureau of exercise greater flexibility in the use of its budgeted funds.

3. Improved Weapons System Management. Because the new system permits more precise inventory control, management can focus on the inventory demands of a particular weapons system. Navy management therefore becomes more responsive to the heightened demand for the various types of inventory control needed because of the increased complexity of today's weapons system—whether it is a Banshee jet fighter, Polaris submarine, or nuclear powered aircraft carrier.

4. Higher Integration of System. In the new system, a single element of data is automatically sent to all places where it will have an impact. This means that instant analysis is possible. In the previous system, a single element of information often had to enter the system two or more times to have its effect on accounting, inventory, or financial records.

5. Increased Personnel Flexibility. All components of the new system will be standard, regardless of location, and thus it will be easier for personnel transferring between locations to assume their duties. Because they will be familiar with the standard systems, break-in periods will be virtually eliminated and personnel productivity thus increased.

6. Improved Management Communication. A standard system means that data reported to Navy management will have been accumulated by uniform procedures, thus reducing chances for misinterpretation, and resulting in increased confidence in the validity of the data. Also, this factor will enhance communication and implementation of action plans by headquarters personnel.

System configuration for the UNIVAC 490 Real-Time System comprises four central

processors with a combined 131,072-word core memory, 59 Uniservo IIIC compatible type units, 7 high speed printers, and 4 control consoles. Real-time means the ability to respond instantly to inquiries from thousands of remote points.

The UNIVAC 490 Real-Time System provides a flexible, economical, and efficient solution of BUSANDA's overall problem because:

- Mass storage is sufficient to contain the inventory balance and other key identifying data for the hundreds of thousands of items under ICP control.

- Inventory can update instantaneously, even while transactions are taking place.

- The system has capabilities to receive a requisition over communication lines from any activity in the Navy complex, treat it with its NAVSTRIP priority, and process it in a matter of seconds.

- The 490 gives millisecond response to each of the thousands of inquiries demanding immediate inventory information in any of a number of classifications or by given topics. For example, if a Federal Stock Number (FSN) is given to the system, it can tell the inquirer what weapons system, or systems, uses the part. Also, if a weapons system number is given the computer, it can print out all parts used in that particular weapons system.

- The system handles all the above work concurrently, receiving requests and transmitting information without apparent interruption of other work being done by the system at the same time.

The four UNIVAC 490 systems will be located at these inventory control points: Aviation Supply Office, Philadelphia; Electronic Supply Office, Great Lakes; and Ordnance Supply Office and Ships Parts Control Center, Mechanicsburg, Pennsylvania.

Computers and Centers, Overseas

The Gamma 10 "COMPACT"

Compagnie des Machines Bull
Paris 20, France

INTRODUCTION

The Gamma 10 "Compact," an electronic data processing machine that uses punched cards as a data medium, is designed to fulfill the needs of medium-sized business organizations.

It incorporates all the advantages of large electronic systems: stored program, integrated, high-speed data processing, plus all the conventional functions previously carried out on individual machines such as a tabulator with connected punch, a calculator, a reproducer - duplicator. The Gamma 10 can also handle certain sorting and merging operations and in this way limits the necessity for machines specialized in this type of work.

The Gamma 10 consists of the following components: a central processor with a variable capacity ferrite core central store and fully-transistorized control and programming circuits; peripheral components for data input and output: a card reader-punch operating at a speed of 300 cards per minute both for reading and punching operations; a printer operating at 300 lines per minute.

Specialized buffer stores act as links between these components and the central store, and provide for complete simultaneity by means of which input, output, and processing units may all operate at the same time.

Physically, the Gamma 10 consists of two units placed at right angles to each other. The first unit includes the central processor, the card reader-punch, and the console; the second is the printer. This layout is designed to facilitate the work of the single operator.

The equipment is easily installed; no special preparation of the site is required, no special air conditioning is needed. It is economical both in the space (160 to 195 square feet) and personnel it requires.

DESCRIPTION OF THE GAMMA 10

Central Processor

The Gamma 10 central processor includes the central processing store, two input buffer stores and two processing stores, programming, arithmetic, and logical processing units, and the control and checking console.

The central, high-speed, ferrite-core store has a basic time cycle of 7 microseconds. It may have a capacity of 1024, 2048, or 4096 characters.

The input buffer core store links the central store with the card reader. It has a capacity of 112 characters and can store quantitative data from all the 80 columns of the card, as well as 32 characters representing qualitative data or indices (card codes, group change signals, and the like). These data are used in directing program operations.

The output buffer core store has a capacity of 200 characters: it supplies the printer (120 print positions per line of print) and the punch station of the reader-punch.

The program circuits for the supervision of instructions and their execution are located in the programming and processing units, as are the arithmetic and logical circuits. Addition, subtraction, or comparison of up to six decimal digits requires 220 microseconds, whereas multiplication of two six-digit numbers requires 5.6 milliseconds and division, 8.4 milliseconds.

The function of the console is to survey program operation and development. Light Signals indicate each step in the execution of a program and the scanning of the contents of the store; control buttons are provided for starting and stopping the operation of the machines and checking the peripheral components.

Input and Output Units

The card reader/punch supervises and updates card files used by the Gamma 10. It reads data, punches data or results in cards into the same or blank cards, inserts new cards into the file, and routes cards from the file into three receiver pockets. It operates at a speed of 300 cards per minute both for reading and punching and is made up of two tracks: the main track contains the file to be processed and is supplied by a hopper holding up to 3000 cards; the secondary track, for the introduction of blank cards, is fed from a hopper holding up to 800 cards. The secondary and main tracks meet beyond the punching station so that new cards may be inserted in the file during operation.

The three receiver pockets have card capacities of 3000 (normal pockets) and 750 and 850 (special pockets). In this way, a file may be updated by substituting cards without rearranging the entire file.

Printer

The printer operates on-line at 300 lines per minute. The 120-position print drum has 60 characters engraved on each wheel.

There are two versions of Gamma 10, one for reading and punching BULL codes and the other for HOLLERITH codes. Character selection is carried electronically. The print area covers about 15 inches and may be used for printing double width commercial statements; at the request of the customer, the printer may be equipped with a double paper feed to produce two statements side by side.

OPERATING CONDITIONS

The combination of these characteristics produces operating conditions which are extremely simple because of the simplicity of writing and developing programs, very handy because of the wealth of subroutines and orders of all kinds, and accurate because of the many checks available to the Gamma 10.

The programmer starts with the flowchart, from which it is easy to define and number the various processing segments; he may also take a count of the various data. Each segment is written up as a separate routine. Instructions are made up of three elements (types of operation, address A, address B) each of which uses a code numbered from 0 to 63.

Since programs are broken down into segments, standard subroutines are easily added, afterwards. Service routines, such as the "current applications routine" are provided so that, for example, a file of punched cards may be run to give various statements, with or without punching of temporary or summary cards. "Area" cards complement the program by indicating the identification number of each area and the number of characters.

Operating is simple: for each processing operation or phase, program cards are entered first, then the area cards. The machine transcodes them into an internal code and supervises qualitative and quantitative data. The console provides an accurate and constant means of following operations.

A complete checking system—checking by key during transfers within the central processor; read check, before processing, between two read stations, punch check by a read station following the punch station; check of transfers to the printer—ensures the accuracy of the work being carried out.

Finally, the Gamma 10 provides an accurate and economical punched card system, from the point of view of installation, as well as operation, and incorporates all the advanced techniques of large electronic systems.

These program lines are made up of segments which define a processing function. The maximum number of segments of a program is 60, and of instruction lines for each segment is 64. This layout simplifies adaption of the flowchart into program segments, each of which fulfills one function—programming of variants and the carrying out of subroutines. Each segment is programmed separately. Sequencing and supervision of these segments is then carried out automatically by the machine.

The set of instructions available to programmers is very complete. It includes input and output instructions, internal transfer instructions, calculation instructions, logical instructions and branchings, and miscellaneous instructions. Input and output instructions are used to move data between the central store and the input-output buffer stores. Transfer instructions are used to move data from one central store area to another. Calculation instructions are carried out by the adder/subtractor; multiplication and division are cabled.

Execution times for these operations, which may vary depending upon the length of the number being processed, are as follows: 220 microseconds for an addition, a subtraction, and a

comparison; 5.6 milliseconds for a multiplication; 8.4 milliseconds for a division (with an operand of 6 digits in all four cases).

Logical instructions are used for comparison of numbers and storing the results in a specialized register. Jump instructions alter the program as a result of a comparison or in accordance with index values. Miscellaneous instructions concern the input of constants and the supervision of indices.

Paper movement is controlled by stored program; stoppage after movement is controlled by an 8-channel lead tape. Ten different movements are possible: movement by single, double, or triple interline spaces and seven jumps each monitored by one channel of the lead tape; the eighth channel is used to indicate that a sheet is full.

GAMMA 10 PROGRAMMING

The stored program of the GAMMA 10 insures flexible, accurate, and very powerful operation for a machine of this type. Gamma 10 programming is designed for machine-oriented problem solution; it insures automatic supervision of data to be processed. Storage locations in the central store and organization for simultaneous operation, are not programmed, but are carried out automatically by the machine.

A - Data Organization

Data used by the program are contained in punched card files. There are several different kinds of data: quantitive data (alphanumeric data to be processed): qualitative data (codes, signs, and the like, which orient or condition processing); before programming, quantitative data are classed according to their nature, measured by number of characters, and identified by a number.

Data are arranged in areas on the cards. The programmer must classify these areas according to nature and length and allocate an identifying number to each. The rest of the operation is automatic: the machine works with these data; it enters them in the store, and records the real address in its registers. When these data are called by their identifying number, it seeks out the data and processes them.

A correspondence table is stored in the area address register so that at any given moment and by means of internal circuits, the table automatically supplies the correspondence between the identifying number and the actual area location address. The area address register contains 63 addresses. The address indicated is that of the first character, or "marker" of the area. This organization relieves the programmer of the problems of addressing and identifying lengths, which complicate program writing and may cause errors.

Qualitative data are those which affect the processing operation. They may be a data sign, the presence of a code in a card, detection of a group change, and so on. Practically, these data bring about variants in the program depending upon whether or not the condition they stand for is fulfilled. They are entered into the machine either by means of codes other than those of the machine itself or as a result of an examination of comparisons; the program examines them by testing for "yes" (fulfilled) "no" (not fulfilled) conditions of the stored positions.

The Gamma 10 resolves this problem in its own simple manner; qualitative data are catalogued before the work is undertaken, and given an arbitrary identification number from 1 to 63. An index selector filters the normal codes and the comparison results of indicative areas (due to the two read stations on the card reader, comparisons may be carried out in desired time) and delivers the "indices" which are stored at addresses allocated to the identifying numbers: indices 1 or 0 enable the execution of program variants. The index selector panel contains 32 index positions.

Program Instructions

By using identifying numbers as symbolic addresses for data located in the high speed store, very short (i.e., three character) program instructions may be used; the first character indicates the type of operation, and the second character usually indicates the address of the second operand.

These addresses are indicated by the identification number of the area to be processed. This number may be from 00 to 63 and is transcoded into a binary number of one character when the program is entered.

Kommission für Elektronisches Rechnen der Bayerischen Akademie der Wissenschaften

Munich 2, Germany

A new computing center has been established by the Kommission für elektronisches Rechnen der Bayerischen Akademie der Wissenschaften in Munich, Germany. Administratively, the center belongs to the Bavarian Academy of Sciences, but is operated jointly by the Bavarian Academy, the University of Munich, the Munich Institute of Technology, and the Max-Planck-Institute for Physics. Other scientific institutions may use the computing center for a nominal fee.

By a grant from the Deutsche Forschungsgemeinschaft the center is equipped with a TELEFUNKEN TR 4 computer with 32-K memory and four tape units. Punched card and punched paper tape input-output, a high-speed printer, and the usual peripheral equipment are available. The monitor system includes an ALGOL compiler.

Document Handler for Banking Application

Standard Elektrik Lorenz AG
Stuttgard, Germany

A versatile document handler has been developed by Standard Electric Lorenz AG., Stuttgart, a German ITT associate. It combines an optical document reader, a printer, an enveloping machine, and a letter distributer. The original application was for the German Post Cheque Service but it will be useful for many other similar purposes.

The documents (up to 4 x 6 inches) are read at a rate of 10 per second. The information may be transferred to a computer, which in turn delivers its results to the high speed printer (15 lines per second). In this original application the documents are cheques and transfer orders. The account read is booked by the computer on to accounts held on magnetic tape. For each account the printing station prints a record of all movements, the final balance, and the mailing address from a customer file tape.

This record is cut and folded to appropriate letter format, all documents (up to 10) concerning the account movements are attached and inserted in a letter envelope. The closed envelopes are distributed to four letter boxes according to the mailing region of the customer's address. The overall speed gives an output of one account record letter per second.

DOCUMENT CODING

All information for automatic handling is printed in CZ 13 characters for optical recognition.

ACCOUNTING

The coded documents pass through a NCR-Pitney-Bowes-Reader-Sorter at a rate of 750 per minute. The sorter has been equipped with an SEL optical reader. The recognized information is transferred to the data processor. Accounting is accomplished until the document is gated into one of 18 pockets of the sorter. All data required for accounting (account number, balance, holds) are available from a magnetic drum store within an average access time of 10 milliseconds. Thus the documents can be accounted in single run without a preceding sorting process.

Further data of the account (mailing address, previous balance) are stored in the master file on magnetic tape. All accounting operations are stored on magnetic tapes, separately for credits and debits, printing, and checking purposes.

SORTING OF DOCUMENTS

Before printing the account statements, all credit documents have to be sorted according to the credit account number. That is done on another NCR-Pitney-Bowes-Reader-Sorter without using the computer. Simultaneously, the computer sorts the debit data stored on the debit tape according to debit account numbers.

PRINTING AND ENVELOPING THE ACCOUNT STATEMENT

Printing the statements requires: The master file tape, the debit tape, and the credit documents. Besides feeding the printer with the appropriate information, the computer checks the new balance of the account against the value, which has been calculated earlier during the accounting process. The credit documents and the account statement are inserted into an envelope for immediate mailing to the holder.

PRINTING THE CHECK LISTS

Printing of check lists is done on a separate high-speed printer. The documents may be read on the same reader as used previously during the accounting process.

OPTICAL CHARACTER READER

The machine reads the ten numerals and four special symbols of the stylized type font CZ 13 (see Figure 1). The construction mode of the characters is of the so-called bicode type, i.e., they are constructed into a grid of 10 vertical stroke elements arranged in two horizontal lines and five vertical columns.

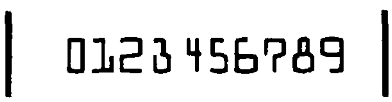

Figure 1.--Stylized type font CZ 13.

The differentiation between either two characters is four stroke elements in average and two elements in the worst case. This means a relative Hamming Distance of 0.20 which is the same value as claimed by the U.S. Standardization Committee X.3-1 for their proposed standard type font built up from 5 x 9 grid elements.

The reader has been adapted to the NCR-Pitney-Bowes-Sorter which handles 750 documents per minute. Since this sorter transports the documents with a speed of 150 inches per second and the characters are printed with a pitch of 10 to the inch, the reading speed is 1500 characters per second. Twice this speed is also possible.

Such a reading speed is relatively high for OCR equipment and is achieved by scanning each character in several horizontal traces in parallel. Germanium photodiodes are used as light transducers, operating in the visible and infrared spectral range with the advantage that the reader becomes insensitive to most kinds of "smudge." For instance, stamps, colour pencils, and ball point and fountain pens will not affect the correct recognition of the characters. Only materials containing carbon like black pencil should be avoided.

The reader is now in production, the first set of three machines is being supplied to the German Post Office for the automatic postal cheque system. The Post Office has already conducted large scale tests with results even better than those achieved with MICR systems used in banking applications.

Recommended printing equipment are electrical typewriters and accounting machines furnished with normal carbon ribbon. Also normal letter press machines can be used. No special inks or ink ribbons are required.

Miscellaneous

Program in Information Processing

Advanced Research Projects Agency
Washington, D.C.

The biggest, fastest digital computers hold more than a hundred million numbers and carry out more than one million instructions per second, but they do not fully satisfy the demands of the Nation's defense. It will help, but it will not be enough, to develop still bigger, still faster, machines. Needed just as much as size and speed of calculation are the flexibility to do whatever is required at the moment and the capability to serve many people at once.

The Advanced Research Projects Agency, in coordination with other government agencies, has started to support research and development strongly to achieve those goals. If the research and development are successful, the implications may be very far-reaching, extending beyond defense into other parts of government and into business, education, research, engineering, and indeed almost every activity involving men and information. The program holds out a special promise of leading to marked increase in the productivity of individuals and groups engaged in intellectual activities.

To bring the great capability of a large-scale computer simultaneously into the offices and laboratories of many men, and to make it helpfully responsive to all their various commands and questions, is a very large task. With MIT's Project MAC (see page 17, this issue DCN) in the effort are the Carnegie Institute of Technology, Stanford University, the Stanford Research Institute, the System Development Corporation, and the University of California. It may be helpful to provide a few facts about the research being conducted at the other institutions contributing to the over-all research program.

Insofar as level of funding is concerned, the System Development Corporation at Santa Monica is the largest contractor in the program. SDC is engaged in research on computer time sharing and computer languages, and it operates for ARPA a laboratory in which command-control information-processing studies are carried out with the aid of a large, time-shared computer, the AN/FSQ-32. This laboratory is used by SDC and by other ARPA-supported research groups.

Carnegie is conducting research in the areas of programming language, theory of computer processes, and man-computer interaction.

ARPA supports two research efforts at the University of California, one on the Berkeley campus and the other at Los Angeles. Berkeley is developing a time-shared computer system with a patch panel at the Berkeley Computer Center connected by data link to the AN/FSQ-32 computer at the System Development Corporation and to computers at Stanford University. The Western Data processing Center at UCLA is connected by data links with several other universities and research organizations in the West. The research at both University of California Centers will be concerned with computer network problems, computer languages, and computer programming. In the research on time sharing and computer networks, the idea is not to have computers talk with computers; it is to have men talk with computers - and to have rapid and convenient access to data and programs stored in computer memories, even at remote locations.

At Stanford University, work is under way on advanced information-processing techniques, on an approach to computer programming called "heuristic programming," and on the foundation of what we hope will become a solid theory of computation.

At the Stanford Research Institute, the main effort is to improve the effectiveness of computer programmers. As has been stated, one of the major goals of the overall program is to increase the responsiveness of the computer to the user. All of ARPA's contractors are working toward this goal. SRI's research is focused on the development and testing of innovations in real-time computer and data display processes and man-computer communication procedures that promise to enhance the programmers ability to accomplish his task.

ARPA realizes that the problems inherent in making on-line computer capability available to a number of users at diverse locations, with

man-computer languages adapted to diverse requirements, and with the capacity for the storage, retrieval, and processing of large amounts of information, is a complex undertaking. It is, however, an undertaking that must succeed if this nation is to use effectively the vast amounts of information now being generated and now required in military planning, development, and operations as well as in manifold processes of science, technology, business, and government. It is believed that the line of development of close cooperation between men and computers, very early steps along which you will see today, will lead to amplification of man's problem-solving and decision-making capability in almost every field of human endeavor.

Use of Technical and Scientific Information

Auerbach Corporation
Philadelphia 3, Pennsylvania

The Advanced Research Projects Agency of the Department of Defense has awarded a contract to the Auerbach Corporation, Philadelphia, Pennsylvania, to conduct a study on how scientific and technical information is acquired and used in-house by Department of Defense scientists and engineers engaged in research, development, test and evaluation. This study is a part of the Department of Defense Scientific and Technical Information Program. The contract, which is expected to amount to approximately $290,000, is scheduled to be completed by the end of 1964.

The study will be directed at defining the types and kinds of information used by the technical and scientific personnel concerned and determining its relationship to decision making and management functions. It is anticipated that this will be accomplished by having personal interviews, with selected personnel within the Department of Defense, which will cover all levels of Research and Development activities. A series of pilot tests will be made to evaluate the overall study procedures before the full-scale study is undertaken.

The study will be under the direction of Walter M. Carlson, Director of Technical Information, Office of the Director of Defense, Research and Engineering.

Auerbach is a technical-services organization specializing in the development and implementation of data and information systems. Its Information-Management Sciences Division, which is conducting the study, is noted for its work in developing information systems to improve the effectiveness and efficiency of business, industrial, and technical operations.

Reorganization of National Bureau of Standards and Office of Technical Services

U.S. Department of Commerce
Washington, D.C.

The U.S. Department of Commerce in February announced that several of its scientific and technical activities are being combined in the interests of efficiency of operation and better service to science and industry.

The activities involved include those of the National Bureau of Standards (NBS), the civilian technology program in textiles, and the Office of Technical Services (OTS).

Under the general administration of the Bureau of Standards the programs will be grouped into four institutes: Institute for Basic Standards, Institute for Materials Research, Central Radio Propagation Laboratory, and Institute for Applied Technology.

Dr. Allen V. Astin, NBS Director, said the changes will permit more effective management, and closer identification of the NBS activities with the specific needs of science, industry, and commerce. This is particularly important in view of the relocation of NBS, now in process, to new laboratories and facilities at Gaithersburg, Maryland.

The move has been under serious study for some time, and involved discussions with scientific, technical, and industrial advisers to the

Department to make certain that the needs of the professional and business communities would be fully and effectively met.

The Institute for Applied Technology brings together previously scattered activities related to the stimulation of technological progress in industry. To the industry-oriented NBS programs are added the civilian technology program in textiles, and the OTS programs of technical information dissemination and the promotion of technological innovation in industry.

The Institute for Basic Standards comprises the long-standing NBS programs in the field of basic measurement standards as well as the recently established National Standard Reference Data Program.

The Institute for Materials Research will combine NBS programs in chemistry and metallurgy, aimed at developing reliable and uniform methods of measurement for the properties of materials. Such data are essential for improving the efficiency of production processes in modern industrial technology.

The Central Radio Propagation Laboratory, located at Boulder, Colorado, consists of those NBS divisions which conduct research and provide essential services in this field to Government and industry.

PLATO II and III

The University of Illinois
Urbana, Illinois

INTRODUCTION

The purpose of the PLATO project (see Digital Computer Newsletter October 1961, July 1962, and April 1964) is to develop an automatic teaching system for tutoring simultaneously a large number of students in a variety of subjects. The central control element of the teaching system is a general purpose digital computer. The PLATO system differs from most teaching systems in that a single high-speed digital computer is used to control all student stations. Thus, it can bring to bear the power of a large digital computer in teaching each student.

INQUIRY TRAINING

During this quarter the PLATO-Inquiry Training lesson (REPLAB) on the bi-metal strip physics experiment was revised. The "experiment laboratory" section of the lesson had originally been written for use in conjunction with a reference notebook. Experiments chosen by the student from the notebook were indicated to the computer by number, and the computer displayed the experimental results on the PLATO electronic blackboard. The supplementary book procedure was awkward, so the revision incorporated the experiments in the electronic book part of the PLATO lesson. The revised lesson (after adaption for use with the PLATO III system) will be used in the next semester by 60 students from Inquiry Training classes now being conducted in the local schools.

Data obtained from the 14 students in the 1963 summer program have been further analyzed. Seventeen REPLAB variables were examined for possible correlation with 32 other intelligence, perception, and cognition variables. The results of this analysis suggested that REPLAB provides a comprehensive and multidimensional analysis of inquiry, and that certain REPLAB variables correlate highly with clusters of other cognitive variables suggesting that at least three factors may be tapped by the test: Cognitive Control, Autonomy, and Impulsivity.

PROOF

The working version of the PROOF program is being used to collect data from mathematics teachers in the Academic Year Institute. This study, like the one conducted with high school students, is intended to discover the characteristic errors made in composing proofs on PLATO. Common mistakes which can be traced to poor design in the program will indicate modifications in the next version.

Work is already underway in writing a new program along the lines of PROOF but with a greatly expanded flexibility. The new program is intended to serve two functions:

1. To provide a system for collecting data on thought processes during mathematical problem solving which is capable of handling a wide variety of mathematical problems including

proofs, solutions of equations, and simplifications, in fields as disparate as algebra, geometry, and the several branches of logic;

2. To provide a system for preparing instructional programs introducing students to the mechanics of rigorous proof in algebra, logic or geometry which actually requires them to construct proofs step by step. The programming flexibility should allow lessons in which students themselves develop a useful set of theorems from a given set of axioms.

PLATO III SYSTEM EQUIPMENT

During this quarter, work continued in the development and construction of circuitry required for the realization of a 20-student-station teaching system.

Circuitry constructed to date includes all logic circuitry required for operation of eight student stations, all storage tube circuitry required for two student stations, all scanner circuitry required for one-half slide capacity, and all video switch circuitry necessary for two student stations. In effect, the above suggests that only two student stations are presently operable.

The remaining circuitry required for full operation of 20 student stations is either under construction or undergoing development. Included in circuitry being constructed is logic and scanner circuitry. Included in circuitry being developed is storage tube video and deflection circuitry, video switch circuitry, and power control circuitry.

PLATO III TUTORIAL TEACHING PROGRAM

During the past quarter, the basic PLATO III tutorial teaching program was completed, checked, and demonstrated. This progress report is, therefore, perhaps a good point at which to review the major features of this program.

The PLATO III tutorial teaching program uses as its core a teaching logic very similar to the old PLATO II tutorial teaching logic. The latter logic, with its main and help sequences, has been described on many previous occasions. The PLATO III tutorial teaching program represents the following major improvements:

1. With each problem in the main sequence, up to eight help sequences may be specified. The help sequence entered when a student requests help is determined by routines which analyze the student answer for any of up to seven types of error. Each of the seven help sequences then addresses itself specifically to pointing out to the student how he can correct the particular error he made. If no such special error is exhibited by the student answer, the program causes the eighth, or general help sequence to be entered.

2. At various points in the main sequence, evaluators may be inserted which compare student performance against specified criteria of performance. If the student has met these criteria, he is allowed to proceed to the next topic. If he has not met the criteria, he enters an "expanded" part of the main sequence. He is given further material (text and/or problems) until he demonstrates a satisfactory ability in dealing with the material. The input to the evaluator routines is data gathered by monitoring routines. Any problem in the main sequence may be designated for monitoring. When this is done, the following data is gathered for that problem and kept in the core store for later use by the evaluator:

a. time required to solve the problem;

b. help required or not (if help is requested, which sequences (cf 1 above) were used);

c. number of wrong answers and type of errors made;

d. computer-provided correct answer or not; and

e. reversal employed in the main sequence.

These data, kept for each monitored problem, are suitably processed by each evaluator and used to determine whether the student should skip or stay with the topic. The demonstration lesson contains three different evaluators of this sort.

3. Up to eight different lessons may be stored in the machine simultaneously.

The demonstration lesson deals with the addition of fractions and is carefully designated to exhibit all the logical features of the PLATO III tutorial teaching program in a minimum of time. Thus, if a student adds fractions correctly but fails to reduce to lowest terms, he is given a different help sequence than if he fails to use the proper method entirely.

The following items remain to be completed during the next quarter:

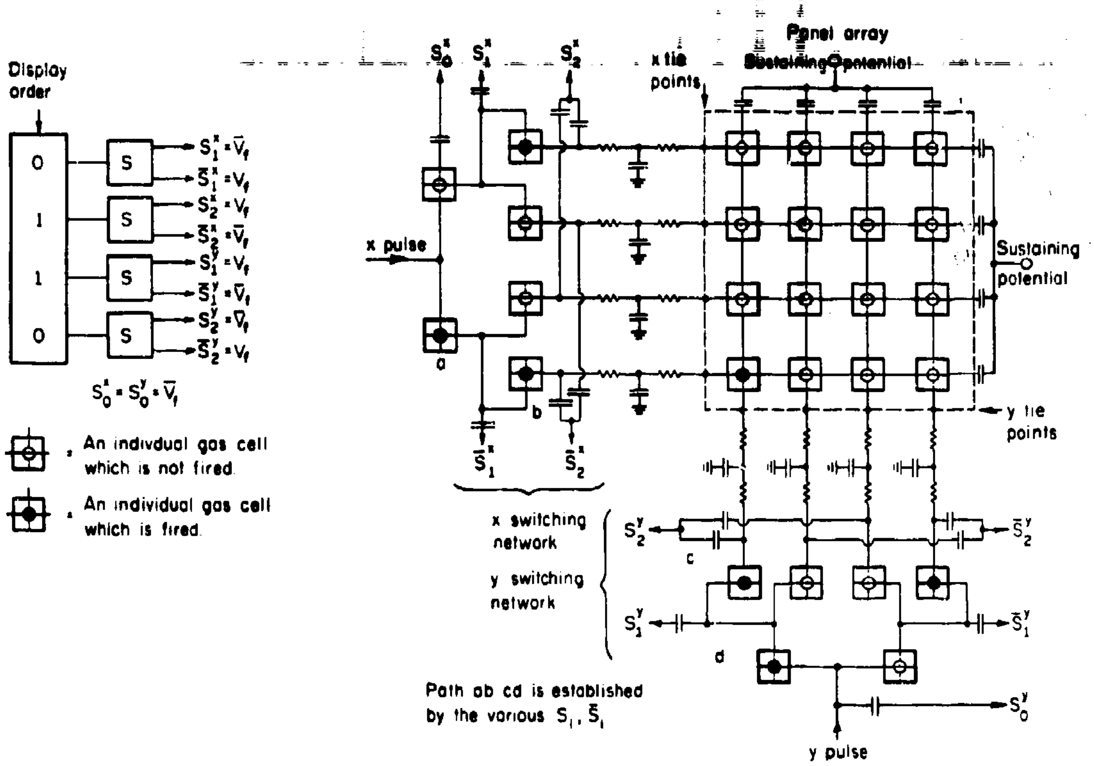

Figure 1.--Method of cell selection.

1. a more convenient loader for getting lesson parameters into the machine than the one presently in use;

2. the completion of the general data-gathering routine which records all student inputs on magnetic tape. These data are used for general evaluation purposes after a lesson and are not to be confused with the monitoring-evaluation routines mentioned previously; and

3. the preparation of general sorting, processing and statistical routines for reducing the data recorded on tape as mentioned in the preceding paragraph.

PLATO COMPILER

A PLATO compiler has been prepared so that non-computer-oriented researchers can prepare teaching logics without relying on the aid of computer programmers. Knowledge of Fortran programming is all that is necessary for using the compiler.

For testing purposes the compiler has been divided into two parts. The first part converts statements into the computer language, and the second part permits the computer to communicate to all of the student stations without interaction. Both parts of the compiler have been completed and are being tested. In the near future we expect to connect the two parts into a single program.

PLASMA DISCHARGE DISPLAY TUBE

The purpose of the plasma discharge display tube is to develop a less expensive replacement for the present storage tube system. The plasma display device would be relatively inexpensive to manufacture and, being inherently a digital device, would display the computer information directly. This would eliminate the need for a digital to analog converter and a sweep generator. The necessary logic circuits could be manufactured in a similar manner as the display tube and could be an integral part of the device.

A plasma discharge display tube consisting of a large number of cells filled with an inert gas was proposed by Lier-Siegler.[1] A switching array has been designed in this laboratory which is a solution for the selection of the elements of such a display device. The wave shape of the sustaining potential is of great importance in preventing races and the firing of adjacencies in the display matrix.

The switching array uses a small number of cells (about 1.6 percent of those of an array of $2^8 \times 2^8$ cells) which are similar to those of the display matrix cells and are suitably interconnected to allow two major simplifications of the switching problem. The first is a great reduction in the number of external control contacts needed, reducing the number from 2^{n+1} to to $2(2n+1)$ where n is the number of bits used for position selection. The reduction is accomplished by integrating the switching network and the display matrix into an easily constructed device. The second simplification is the direct use of the digital binary coded information for selecting a spot without using an intermediate digital to analog device. Each bit in the binary representation for the cell is converted to an alternating current voltage (R.F.) which is connected directly to the switching device without needing extra interconnections.

Figure 1 illustrates the method of cell selection for a 4×4 array and a display code of 4 bits (0110). The first two bits, 01, select the x position and the last two, 10, the y position. It can be shown that all the cells may be interconnected so that only two ends and their photoceramic material are needed for the whole switching network. Since the necessary resistors and capacitors could be combined with the cells in a printed circuit fashion, the switching network and the display array could be an extremely thin device whose overall width need not exceed twice that of the display matrix alone.

The switching scheme and method of gating spots of the storage tube has been simulated using Ne-2's for the plasma elements. A narrow, asymmetrical rectangular voltage was needed for the sustaining voltage to eliminate races and firing of adjacencies in the array. With this sustaining voltage, any sequence of elements in the array could be fired.

[1] Electronics, 24-26 (Jan. 25, 1963).

Project MAC—Current Status

Massachusetts Institute of Technology
Cambridge 39, Massachusetts

INTRODUCTION

The Massachusetts Institute of Technology is participating in a major national program of research on advanced computer systems and their exploitation. The program is sponsored by the Advanced Research Projects Agency of the Department of Defense, and the contract to initiate the effort at M.I.T. was awarded by the Office of Naval Research on behalf of ARPA during 1963.

The research at M.I.T. is being carried out under the project name "MAC," (see Digital Computer Newsletter April 1964) an acronym derived from two titles: machine-aided cognition, expressing the broad project objective, and multiple access computer, describing its major tool. The project director is Dr. Robert M. Fano, Ford Professor of Engineering and Professor of Electrical Communications. Project MAC is located adjacent to the M.I.T. campus at 545 Technology Square, Cambridge.

Project MAC is capitalizing on a long history of pioneering work on computers and information processing at M.I.T. and M.I.T.'s Lincoln Laboratory, which includes such milestones as the analog computer of Dr. Vannevar Bush prior to World War II, Whirlwind I, the SAGE System, and the TX-2 computer. The present MAC computer system is based on recent research on time-sharing at the M.I.T. Computation Center.

OBJECTIVES

The broad goal of Project MAC is the experimental investigation of new ways in which on-line use of computers can aid people in their creative work, whether research, engineering design, management, or education. Thus, an essential part of the project is the evolutionary development of a large, time-shared computer system that is easily and independently accessible to a larger number of people, and truly responsive to their individual needs. It includes the development of languages that are suitable for man-machine interaction and capable of evolving with the conceptual structure of the

field in which they are used. The keynote is ease of access, both physical and intellectual, leading to an intimate collaboration between the human user and the computer in a real-time dialogue on the solution of a problem, in which they each contribute their best capabilities: for the man—imagination, insight, inspiration and judgment; for the computer—enormous computing power, high-speed data retrieval from a vast store, and the ability to handle the details of very complex logical processes.

An equally essential part of Project MAC is a program of basic research aimed at providing better theoretical tools for describing, analyzing, and synthesizing complex logical structures and procedures. Such tools are needed to deal effectively with increasingly complex programs and with problems such as those arising in the planning and execution of large engineering and managerial tasks—problems which in the past could be dealt with only through human judgment and the skill of experience.

The system goal of Project MAC may be regarded as the development and operation of a community utility capable of supplying computer power to each "customer" where, when, and in the amount needed. Such a system is in some ways analogous to an electrical distribution system. That is, it must provide each individual with logical tools to aid him in his intellectual work, just as electric tools are today aiding him in his physical work. The present status of the computer as a source of logical power is similar to that of the early steam engine as a source of mechanical power. The steam engine could generate much more power than could any man or animal, and therefore it could do large jobs well. The power generated, however, could not be supplied on an individual basis to aid men in their daily work, until the advent of electrical power distribution.

The analogy between electric power and computer power illustrates only one of the aspects of a computer utility, namely its ability to provide the equivalent of a private computer whose capacity is adjustable to individual needs. Of perhaps greater importance to the customers are the implications of a vast secondary memory in the same system. From such a secondary memory each customer can retrieve programming aids, translators for a variety of programming languages, information about a variety of subject including instructions on how to use the system itself, and of course his own private files of data and programs.

Furthermore, group files can be developed and stored in the secondary memory by people with common interests, who can then use the system as a communication channel for cooperative operation. For instance, programmers working together on a complex program can check continually the status of the overall program as each modifies and debugs his own contribution. The problem of sustained and closely-coupled intellectual cooperation by several people on the development of a single large system is a formidable one for which the techniques sought by Project MAC offer one of the very few hopes.

THE INITIAL MAC COMPUTER SYSTEM

The primary terminals of the MAC system are, at present, 40 Model 35 Teletypes and 28 IBM 1050 teletypewriters. Two of the terminals are located at Lincoln Laboratory in Lexington, five at the homes of key members of the MAC staff, and the rest in various offices and laboratories on the M.I.T. campus. Each can dial, through the M.I.T. private branch exchange, either the IBM 7094 installation of Project MAC, or the similar installation of the M.I.T. Computation Center. The supervisory program of the two computer installations may, independently, accept or reject the call. Each installation can provide prompt service to as many as 24 simultaneous users. The number will increase, and hopefully double, within the next few months.

In order to provide convenient long distance access, the MAC system is connected to the TELEX network operated by the Western Union Company and will be connected shortly to the TWX network operated by the American Telephone and Telegraph Corporation. The TWX terminal alone can reach approximately 65,000 Teletypes, and the TELEX network provides access from terminals in Europe as well as in the United States. Some tests and demonstrations have been conducted from European locations, and experiments are being planned in collaboration with a number of universities to provide further experience with long distance operation of the systems.

The operating program of the MAC Computer System is the Compatible Time Sharing System (CTSS) an evolving program developed by the M.I.T. Computation Center whose first public demonstration took place in 1961. CTSS includes executive, scheduling, debugging, assembler-compiler, and input-output facilities. The programming languages presently available in the system are FAP, FORTRAN, MAD, COMIT, LISP, SLIP, a limited version of

ALGOL and two problem-oriented languages for Civil Engineering, COGO and STRESS.

The system is rapidly evolving through the addition of new language facilities and other utility programs and programming aids. The operating program itself is now being modified by system programmers working on-line, and modifications are occasionally introduced without even interrupting the operation of the system. In spite of its embryonic nature, the system is already proving to be a powerful aid to research in various fields.

The users of the MAC system include faculty and students from a dozen academic departments, and research staff from five major research laboratories. The disciplines represented range from engineering to psychology, from physics to management, from metallurgy to political sciences.

In a typical programming session at a terminal, the user first logs in, giving his identification. He can then type in a subroutine, perhaps using the MAD language, and then call for a printout of his input, edit it to correct errors, and call for a MAD compilation. The resulting binary program, possibly with other programs previously compiled, and then be loaded and run. If the run is unsuccessful the user can request post-mortem data to assist in locating the fault. If necessary, the user can examine the contents of machine registers, correct the source program, recompile it, and so forth (perhaps several times). To terminate the session the user logs out, at which time he receives from the supervisory program accounting data indicating how much actual computer time he has used. Users' programs and data are stored in the disc files of the system, together with compilers and other public programs. Thus a user can interrupt his work whenever he wishes, with the assurance that he can start again, exactly from where he left off, at his next session at a system terminal, perhaps hours or weeks later.

CTSS allows a conventional batch-processing load to be operated as "background." Any computer capacity not demanded by the time-sharing users is absorbed by the back-ground.

While Teletypes and other typewriter-like terminals are adequate for many purposes, some applications demand a much more flexible form of graphical communication. An excellent example of graphical communication arose two years ago on the Lincoln Laboratory TX-2 computer in connection with the doctoral thesis of Ivan Sutherland. This work, in the general area of computer-aided design, is directed toward "tightening the loop" in the design process through use of a computer with appropriate terminal equipment. Using such a terminal, and aided by the computer, the designer might sketch in a drawing of a mechanical part using a "light pen" or other device. Working with his visual display the designer could then modify his drawing as he worked and then perhaps subject the partially designed part to simulated testing by indicating at his display the application of loads and having the computer present the reaction of the part such as deformation, failure, and the like. When the designer is satisfied, he might then press a button which causes the computer to produce a tape to control a machine tool to actually produce the part.

The initial model of a display console developed by the M.I.T. Electronic Systems Laboratory for computer-aided design is now operating as part of the MAC time-sharing system. The console includes an oscilloscope display with character generator and light pen together with some logical capability to simplify the task of the computer in maintaining the display. Communication with the computer can be achieved by means of the light pen, and also through a variety of other devices—knobs, push-buttons, toggle switches, and a typewriter. The meaning of a signal from one of these input devices is entirely determined by the program in the computer. There is no "wired-in" local significance. Thus, the console is an extremely flexible terminal which can be useful in many applications.

The console communicates with the 7094 central processor through the direct-data channel, and the display data are stored in the central memory of the 7094. Thus, the console must be located in a room adjacent to the computer installation. Remote operation would require the addition of a memory and some processing capacity for local maintenance of the display.

The equipment configuration of the MAC computer installation is illustrated in Figure 1. The IBM 7094 central processor has been modified to operate with two banks of core memory, each consisting of 32K words, and to provide facilities for memory protection and relocation. These features, together with an interrupt clock and a special operating mode (in which input-output operations and certain other instructions result in traps) were necessary to assure successful operation of independent programs coexisting in core memory. One of the memory banks is available to the users' programs; the other is reserved for the supervisory

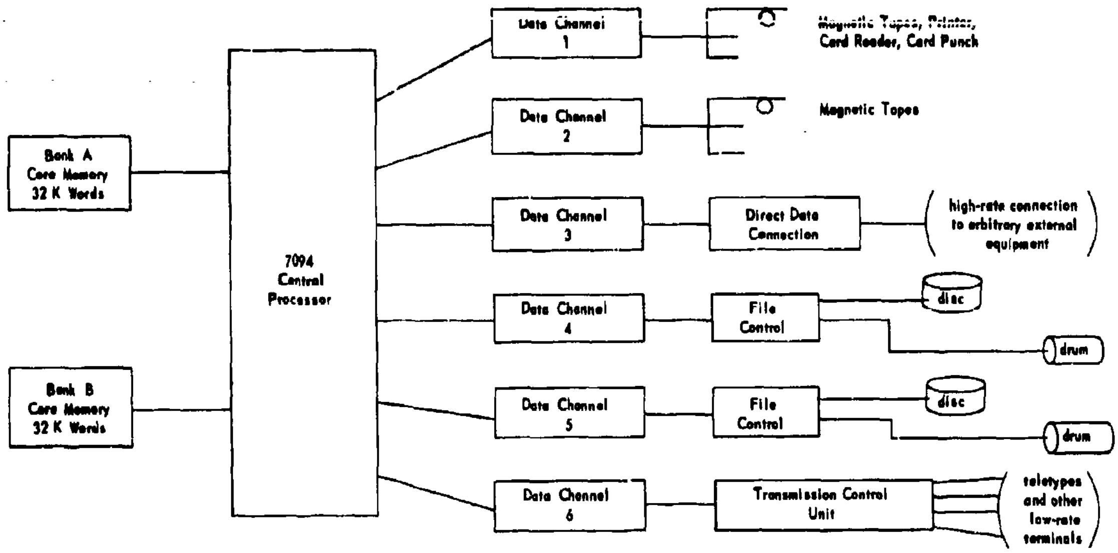

Figure 1.

program of the time-sharing system. The second bank was added to avoid imposing severe memory restrictions on users because of the large supervisory program, and to permit use of existing utility programs (compilers, and so on), many of which require all or most of a memory bank.

The central processor is equipped with six data channels, which are, in effect, small special-purpose computers. Two of the data channels are used as interfaces to magnetic tapes, printers, card readers, and card punches. A third data channel provides direct data connection to terminals that require high-rate transfer of data, such as the special display console mentioned above.

Each of the next two data channels provides communication with a disc file and a drum. Each disc file can store up to nine million computer words and each drum up to 185 thousand words. The time required to transfer 32K words in or out of core memory is approximately 2 seconds for the disc file and 1 second for the drum. The two disc files, which have a total capacity of 18 million words, are used to store the users' private files of data and programs, as well as public programs, compilers, etc. The two drums are used for temporary storage of active programs.

The transmission control unit is a stored-program computer which serves as interface between the sixth data channel and up to 112 communication terminals capable of telegraph rate operation (approximately, 100 bits per second). Higher rate terminals can be readily substituted for a corresponding number of these low rate terminals. All such terminals are compatible with Bell System data sets.

The MAC installation includes also a Digital Equipment Corporation PDP-1 computer. It was acquired to permit early experimentation with light-pen interaction with a display and for other very high-speed interaction work. It includes a 16K-word core memory, Microtapes, a high-speed channel, and a scope display with character generator and light pen. The PDP-1 computer will be connected to the IBM 7094 via a telephone line and alternatively through the direct-data channel.

Computer Predicts Living Conditions in Underground Protective Structures

National Bureau of Standards
Washington, D.C. 20234

The National Bureau of Standards, U.S. Department of Commerce, in cooperation with the Office of Civil Defense, has developed a method for predicting environmental conditions in proposed underground protective structures.[1] The method, devised by Dr. T. Kusuda and P. R. Achenbach of the Bureau staff, employs a digital computer simulation technique and gives results that compare favorably with experimental observations. Such calculations will be useful in designing and evaluating underground fallout shelters in locations where earth and climatic temperature data are available.

Some of the earliest studies of fallout shelters were made to evaluate their structural safety and fallout protection. More recent experimental investigations conducted at the Bureau[2] have indicated the importance of the thermal environment upon occupants in fallout shelters. The metabolic heat generated by the shelter occupants and heat produced by internal lighting or power systems must be dissipated either to the surrounding earth or to the ventilation air. The hour-by-hour balance between the generation of heat and its removal by transmission or ventilation determines the overall shelter temperature. Likewise, the humidity in a shelter depends on the dynamic balance between moisture evaporation and condensation and moisture removal by the ventilation air.

The present investigation was undertaken to evaluate the feasibility of using the digital computer to solve the problem of simultaneous exchange of heat and water vapor among human occupants, ventilation air, and the walls of a three-dimensional earth cavity at finite depths below the earth's surface. The earth temperature surrounding the cavity during the occupancy period was calculated by a finite difference time iteration technique. Solar radiation and ambient air heat exchange with the earth's surface over the shelter were also included in the calculation.

The Bureau's computer program can predict shelter air temperature, relative humidity, shelter inner surface temperature, and shelter inner surface heat flux at two-hour intervals during a 14-day occupancy period. The computer results compared favorably with the data observed for the same time period in two prototype shelters. In one of these, a six-man family-size shelter located on the Bureau grounds, data were obtained during one winter and two summers. In the other structure, an 18-man community shelter located at the University of Florida, data were obtained during one summer.

Although finite difference solutions to differential equations are inherently subject to errors due to the finiteness of the matrix grid and to rounding off of the significant figures during iterative calculation steps, the accuracy of predicted environmental conditions for an actual shelter depends primarily on the reliability of input data. These data include thermal properties of the earth, outdoor weather conditions, initial earth temperature profile, and surface heat transfer coefficients. A major advantage of the computer technique in this application is that the number of simplifying assumptions for the calculation can be significantly decreased, with a corresponding increase in the probable reliability of the computed results.

The mathematical relations necessary for solving the three-dimensional problem have been written in Fortran computer language and programmed into a 7090 computer. A listing of the Fortran program as well as the assembled binary card deck are available from the Bureau.

The program is being applied to the other larger-size shelters for further comparison and will eventually be used to study the effects of various design parameters. Similar three-dimensional heat transfer problems in underground cavities other than fallout shelters can also be analyzed by this program with some modification of the external boundary conditions of the system.

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[1] Tamami Kusuda and P. R. Achenbach, "Numerical analyses of the thermal environment of occupied underground spaces with finite cover using a digital computer," American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Preprint (1963).

[2] P. R. Achenbach, F. J. J. Drapeau, and C. W. Phillips, "Environmental characteristics of a small underground fallout shelter, ASHRAE Journal 4, 21 (1962). Also, Simulated occupants aid study of family-size underground fallout shelter, NBS Tech. News Bull. 46, 26-30 (February 1962).

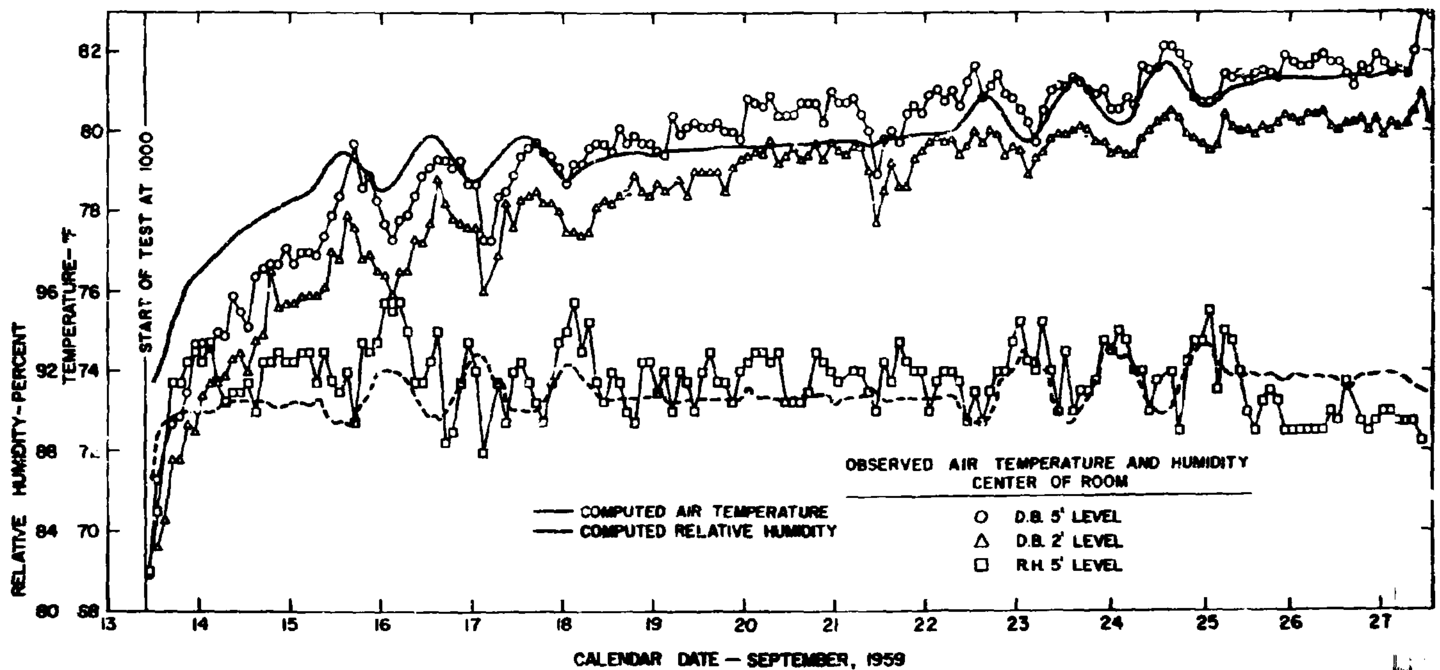

Figure 1.—Computed values of air temperature and relative humidity superimposed on the experimental data observed during one summer test in the NBS family-size fallout shelter

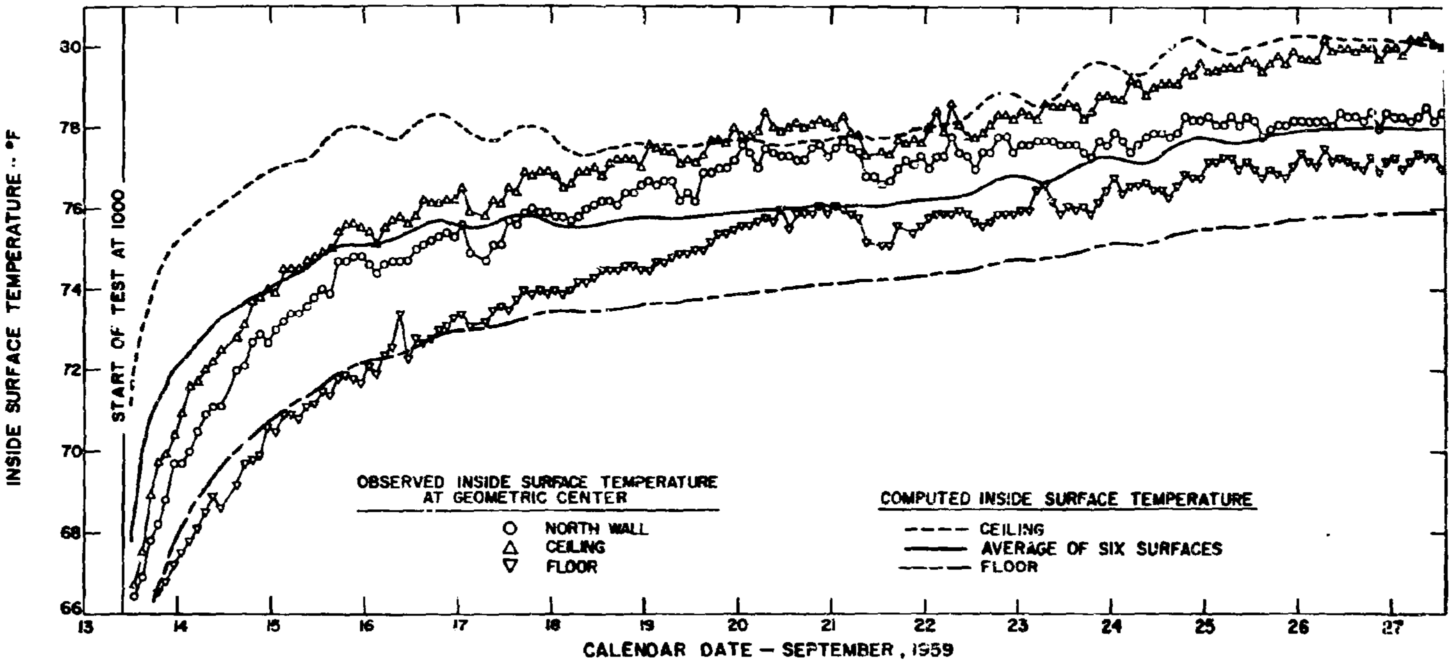

Figure 2.--Computed values of inside surface temperatures of the floor, the ceiling, and an average of all six exposures of the NBS family-size shelter are plotted here with similar observed experimental data for north wall, ceiling, and floor surfaces during one summer test

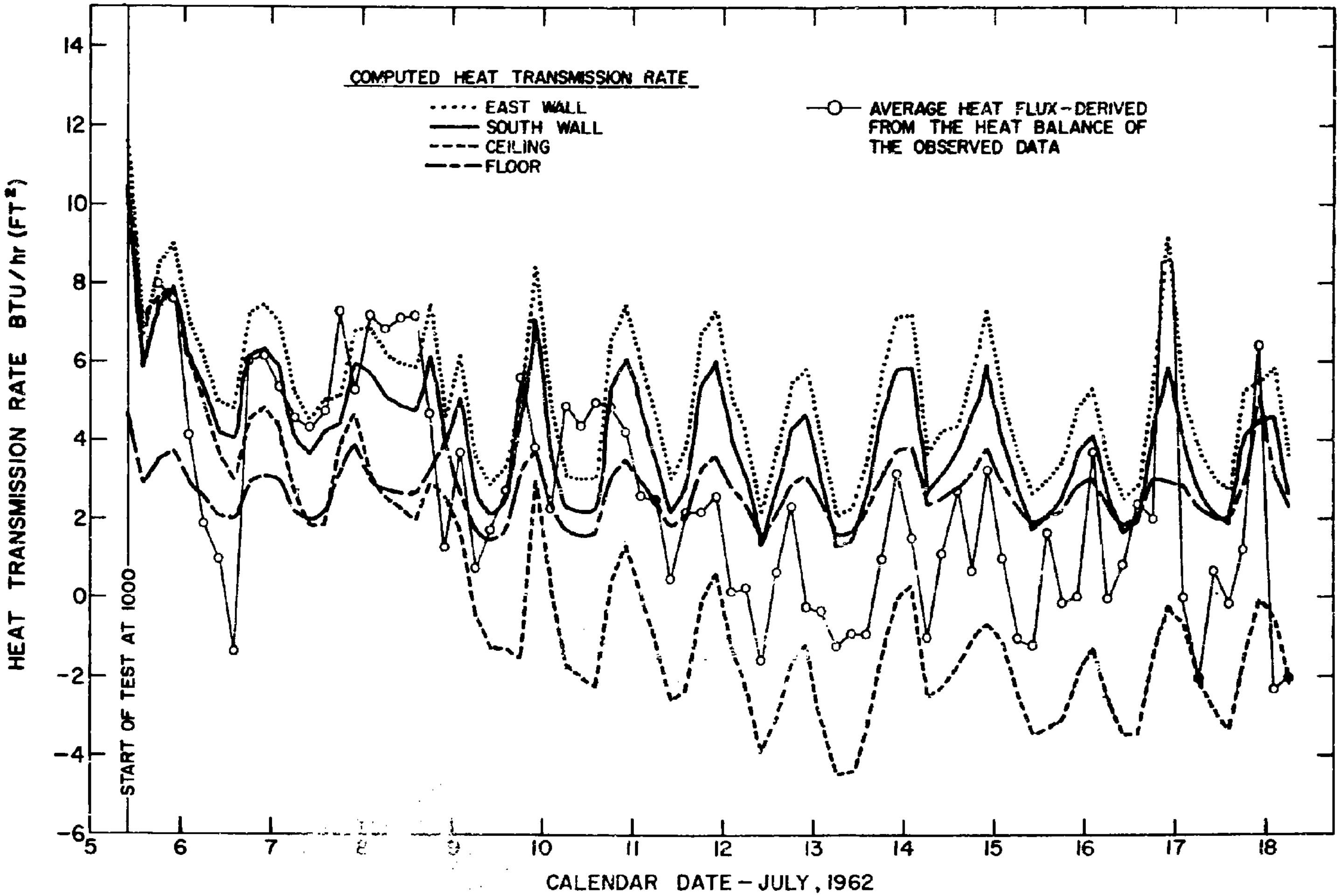

Figure 3.--Computed values of heat transmission rates through floor, ceiling, and the east and south walls of the 18-man shelter at the University of Florida during a summer test are shown here with the curve for the observed average heat absorption per unit area for the entire inside surface

Computer Selects Best Airmail Routes for Faster Delivery

National Bureau of Standards
Washington, D.C. 20234

Computer programmers at the NBS Institute of Applied Technology[1] (U.S. Department of Commerce) have devised a program for selecting the best routes for intercity mail. Bernard M. Levin and Stephen Hedetniemi of the Institute's Information Technology Division developed and tested this program, which is designed for planning mail transportation using the IBM 7090 computer. The same methods can be used to select air, marine, or surface routes by both shippers and carriers in industry and government.

Selecting the best possible routes for mail transportation is a problem of very practical interest to the Post Office Department. The selection must be made on the basis of speed, desired departure or arrival time, cost, and reliability. The complexities of route selection must be dealt with on a massive basis in a short period of time twice a year, when schedules are changed with shifts to Daylight Saving Time and back. Selecting routes by computer should help ease the time pressures.

The so-called "shortest path problem," of which the selection of the quickest or cheapest route is a variant, has attracted the interest of mathematicians in the past, and more recently of computer technologists. The Post Office's problem of routing airmail served as a real problem around which the Institute could develop theoretical and practical programming techniques. In developing this method of route selection much of the actual computer programming was done by Mrs. Waveney Bryant, of the Post Office Department.

The procedure now being introduced by the Post Office is different from but related to the Institute's, and was developed by the Post Office subsequent to the Institute's program. The Post Office system is geared to its specific problem, rather than to the more general problem. It searches for necessary transfer routings by means of IBM 1401 computers, which have recently become standard equipment in that Department. Either program can be used to find the cheapest and fastest routes that can be formed from available air mail flights.

PATH SELECTION BY COMPUTERS

High-speed electronic computers are well-suited to the task of treating a large quantity of data to construct and evaluate possible routes. Furthermore, similarity of this problem to the shortest path problem, for which computer solutions have already been obtained, suggested possible approaches.[2,3] Such computer programs operate by applying algorithms, or mathematical formulas, to obtain solutions.

The algorithm used for the machine solution of the Post Office problem[3,4] was adapted for computer use by means of a program written in FORTRAN, one of man's "computer languages," for the 7090 computer. The program is capable of making route selections from among 2000 trip segments, including up to 80 transfer points.

ROUTE SYNTHESIS

The essential characteristic of the program is that it first determines all usable routes and then makes selections from this list of routes. It uses as input data punched cards giving for each possible link the name of the airline, the flight number, the airport and time of departure, and the airport and time of arrival. Each of these 2000 trip segments is considered as a single-link route and listed as a route for its origin-destination pair. Then each possible two-link route formed by joining contiguous

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[1]As the result of a reorganization effective January 30, 1964, the National Bureau of Standards now consists of (1) the Institute for Basic Standards, (2) the Institute for Materials Research, (3) the Central Radio Propagation Laboratory, and (4) the Institute for Applied Technology.

[2]R. Bellman, Quarterly of Applied Mathematics 16, 87-90 (April 1958); G. B. Danzig, Management Science 6, 187-190 (Jan. 1960); and M. Pollack and W. Wiebenson, Operations Research 8, 224-230 (March-April 1960).

[3]G. J. Minty, Operations Research 6, 882-883 (Nov.-Dec. 1958).

[4]B. M. Levin and S. Hedetniemi, "Determining fastest routes using fixed schedules," Proceedings of the Spring Joint Computer Conference (1963).

single-link routes is compared with previously found routes providing the same services. Promising routes for each origin-destination pair are retained on the list in the machine memory and all others discarded. The computer goes on to form, compare, and retain selected routes by this process until the routes of m + 1 links offer no better route than those offered by the collection of m-link and shorter routes. At this point the machine memory contains a list, for each origin-destination pair, of all routes which could possibly be named as the best route for the times being considered.

TRANSFERS

Transfer time has an effect on the reliability of routes. More time must be allowed for interline transfers than for intraline ones; these transfer times are also related to the size of the airport. The computer was programmed to include correct transfer times, based on rules previously worked out, in synthesizing valid routes.

Generally speaking, the more time between a mail movement's arrival at an airport on a flight and its departure after transfer, the more reliable the route. However, the difference in time required for interline and intraline transfers at any airport creates the interesting possibility of a route having an interline transfer actually being less reliable than one similar, but using a parallel intraline transfer and departing at the same time, or even slightly earlier. To avoid the errors resulting from using time-on-ground as the sole indicator of transfer reliability, the computer is programmed to search, where an interline transfer is tentatively selected, for earlier outgoing flights offering the same or better reliability. An intraline transfer found in this way could be more reliable and would offer the additional advantage, in most cases, of lower cost.

COST OF ROUTES

Cost, as well as speed and arrival time, is a criterion for the selection of routes. The Post Office pays for air transportation on single carrier routes at rates consisting of a loading charge (based on the airport size) and a transportation charge (based on the shortest single-carrier distance). No additional charge is made for intraline transfers. Each airline participating in an interline route, however, is paid the loading charge for the airport at the start of its portion of the route, plus the transportation cost for its continuous portion. The machine program considers these charges in selecting routes.

SELECTION OF BEST ROUTE

The many routes synthesized for each origin-destination pair are listed in the computer memory. The program instructs the computer to punch a card identifying the optimum route, and to print out a number of "next best" routes. Each next-best route is paired with an indication of the reason it was not selected as the best. The printout facilitates identification of next-best routes having outstanding characteristics and evaluation of possible tradeoffs of time with cost.

As this route-selection program is still an experimental tool, the NBS scientists have experimented with the consequences of varying selection criteria. Under one set of rules the cheapest route leaving after the required origin departure time, and arriving before the desired destination arrival time, is selected. The printout lists the next best routes in order of cost. Speed is the major criterion under another set of rules. The selections made using the various criteria are being compared to determine the best way of solving routing problems.

The route selection program has been tested on the 7090 computer, which took only 1 minute to find the preferred paths from 1 city to 83 others for a given departure time. The program has been applied only to departures after 6 p.m. and arrivals before 8 a.m. the following morning (exclusive of Saturday night and Sunday morning), the time of primary interest to the Post Office.

Although this route selection program, as devised by the Institute, could provide specific assistance to the Post Office, the techniques used also have obvious application to selection by carriers or users of air, rail, bus, truck, or composite routes. These techniques could also be used to determine the usefulness of proposed additional links. Continuing work at the Institute in this field is directed at reducing the computer capability required to make the selection, and using a "gateway" approach to permit dealing with only part of the data at once.

100,000th Automated Purchase Order

U.S. Navy Aviation Supply Office
Philadelphia 11, Pennsylvania

The Navy Aviation Supply Office (ASO) recently issued the 100,000th purchase order processed under its advanced automated purchase order system, to Harold Bayer, Product Support Manager, Douglas Aircraft Co., Long Beach, California.

Since March of 1963, when the Northeast Philadelphia Naval activity became the first federal organization in the nation to fully automate the processing of small purchase orders, 100,000 such orders, with a monetary value of $24,000,000 have been processed.

Automation of the purchase orders required for world-wide Naval Aviation stock replenishment has resulted in administrative savings in excess of $100,000. Besides the monetary savings to the country's taxpayers, the new process has greatly reduced the time required to fill requisitions from the Navy's Aviation Supply Distribution System, consisting of a vast complex of ships and shore stations. There are also indications that the process has greatly simplified the supplier's part in the buying cycle.

The automated purchase order is the end product of a fully automated system—starting with the incoming requisition, and going through a multiphase procedure that finishes with the electronic preparation of an order. It is complete to the mechanically affixed official signature of the contracting officer.

Basically, the procedure involves the following steps:

1. The needs of the fleet are determined by a computer which has been fed requisition information from all over the world. These needs are translated on to a magnetic tape in terms of the quantities and destinations of the required items.

2. The requirements tape is automatically matched against a tape file of ASO suppliers.

3. Requests for Quotation (Electronic Accounting Machine cards) are produced by a computer. One card for each potential supplier is produced for each item and destination.

4. Request for Quotation (RFQ) cards are sent to all potential ASO suppliers of each item needed.

5. The supplier enters price, delivery data and discount terms on the RFQ card and sends it back to ASO.

6. An ASO buyer determines acceptability of quotations and selects supplier. (This is the only human decision in the system.)

7. Acceptable quote is fed to the computer, which produces the purchase order.

By the end of June of this year, the price catalogs of various companies will be stored in the ASO computer. Price and delivery information will be obtained from these catalogs and priced purchase orders will be produced automatically from the computer.

With order number 100,000, ASO approaches its second year of automated purchasing for the support of Naval and Marine aircraft throughout the world. Continuing research promises technical refinements that will broaden the scope and effectiveness of this phase of ASO's support of the fleet.

Advanced Concept Management Information System

U.S. Navy Bureau of Ships
Washington, D.C. 20360

The Bureau of Ships' new Management Information System (MIS) represents an advanced concept that now makes it possible for Navy management to base their operating decisions on information that is more timely and accurate than has ever been available in the past.

Such a far-reaching system, incorporating the best ideas of Navy management and American industry, was necessary because last year's data-processing equipment and programs are no longer able to keep up with the demands for information about workloads, schedules, inventory, and procurement.

From this centralized and standardized data-processing system are coming significant benefits to Shipyards, and to the Navy overall:

- Improved management decisions
- Increased operating efficiency through lower inventories
- Better workload forecasts
- Improved material forecasts
- Better scheduling
- Lower data-processing costs
- Increased mobilization capability
- Faster engineering design
- Reduced engineering costs

Under the previous computer programs, each technical bureau and field activity had almost complete authority to determine its need for a computer, which unit to buy or rent, and what programs to feed it.

But under the spur of further integration to meet today's defense needs, the technical bureaus now exercise centralized direction and control by developing and implementing uniform procedures in field activities.

The key benefits realized from such an approach is the fact that activities can now exchange programs, thereby eliminating duplication of effort on such items as systems development, programming, and program maintenance.

Updating Shipyard computers meant it was vital to install a system that represented a flexible, economical, and efficient solution to the problem. For that reason, the Boston Naval Shipyard has in place the UNIVAC III—a completely transistorized system with a larger memory, and a tape processing speed that is 25 times faster than the unit it supersedes. The complete system in Boston consists of a high-speed printer, card-punch, high-speed reader, central processor, and tape system. UNIVAC III executes most instructions in 8 microseconds, and as many as 13 operations can proceed in parallel under the control of several concurrently running programs.

UNIVAC III also accepts information in COBOL (COmmon Business Oriented Language). This permits the same program to be processed on other computers without re-programming, thus saving time and money.

Also, uniform production planning and control procedures for all Shipyards means that the man on the job receives the job order, the material, and the plans he needs to do the job—faster, and when and where he needs them.

This system also helps management to forecast workloads faster and more accurately, to reschedule work as special jobs require, to maintain better inventory control, and to improve the procurement of materials.

Boston Naval Shipyard had the lead in installing the new UNIVAC III, and in developing uniform procedures in the area of production planning and control. Other Shipyards participating in this program are Portsmouth, Philadelphia, Norfolk, Long Beach, San Francisco, and Mare Island.

This new Management Information System is another progressive step to help the Navy even more effectively support the Nation's overall defense mission in this atomic age.